Dam Removal Project Overview

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Commonwealth of Massachusetts

RIVERWAYS PROGRAM

Building Partnerships, Protecting Rivers

Talk Outline

- Characteristics of River Health
- Dam Impacts (ecological and economic)
- Dam Removal History
- Dam Removal Components
- Some Recommendations and Frequent Challenges

Characteristics of Healthy Rivers

Characteristics of River Health

- Water Quality
- Water Quantity (and flow regime)
- Connectivity
- Complexity

- These characteristics allow for healthy and diverse aquatic populations
- Rivers are dynamic

Water Quality

- Pollutants
  - Non-point
  - Point source
- Dissolved oxygen
- Temperature
- Nutrients
  - Can be too low or too high

Water Quantity and Flow Regime

- Quantity
- Flow Regime
  - Timing
  - Frequency
  - Magnitude
  - Duration
  - Rate

- Aquatic species have evolved and adapted to a specific flow regime

Connectivity

Rivers are long, linear ecosystems

River species need different habitats:

- Seasonally
- Through life history
- Refuge from events
- Genetic diversity

Connectivity

- Upstream and downstream connectivity
  - In water
  - Along bed
  - Along banks
  - Along floodplain
- For species, sediment, and debris

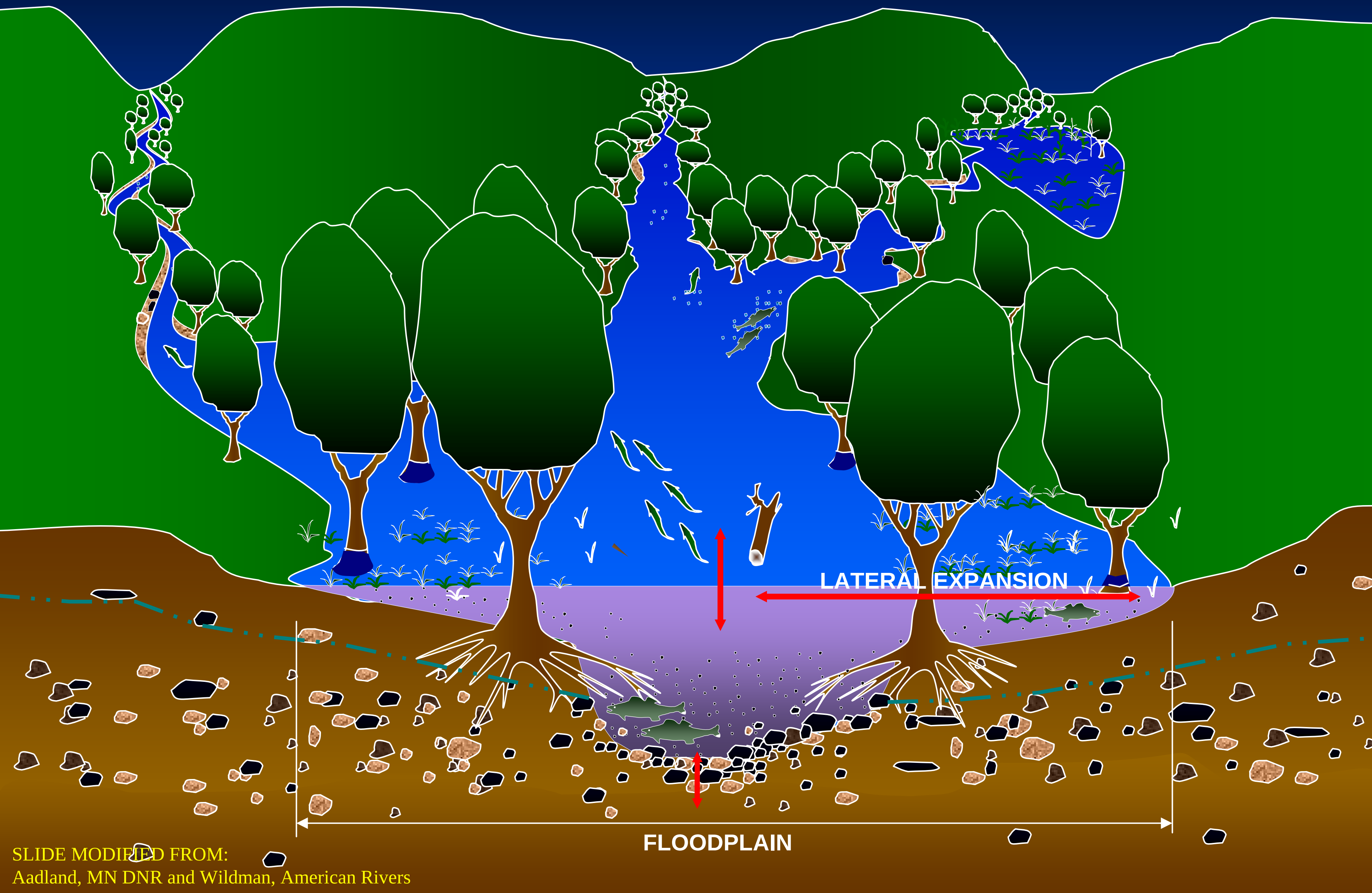
CONNECTIVITY OF A RIVER

Normal Flow

SLIDE MODIFIED FROM:
Aadland, MN DNR and Wildman, American Rivers

CONNECTIVITY WITH FLOODPLAIN

Flood Flow: Incision reduces this connectivity



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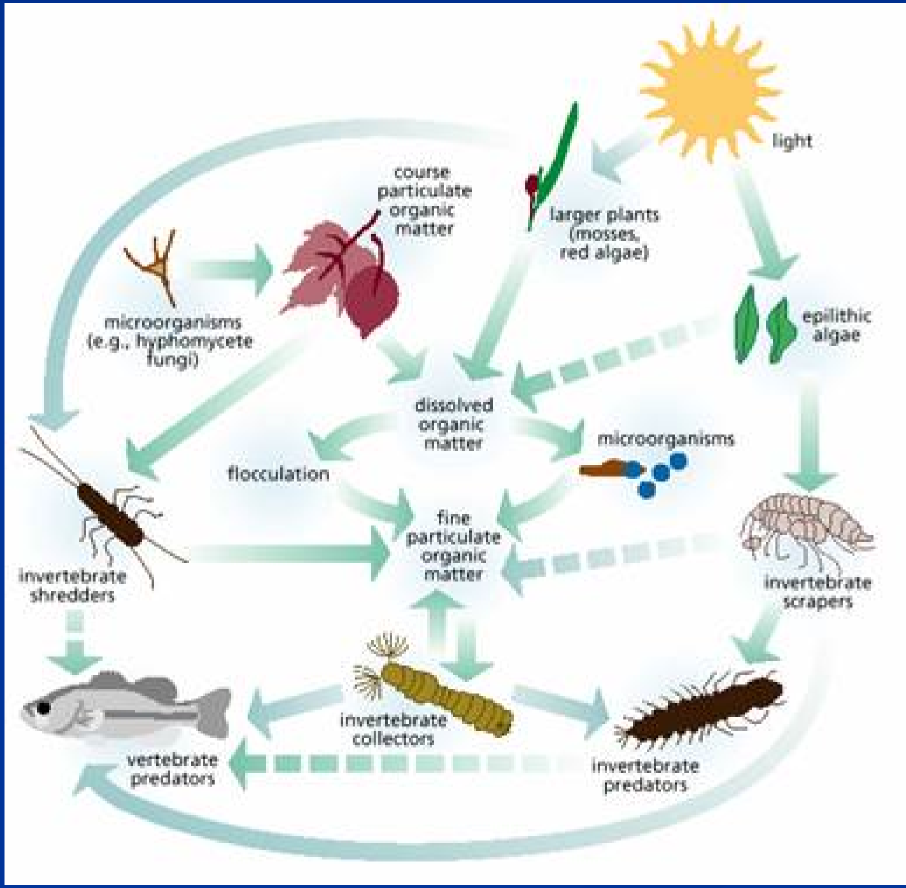
Ecosystem Inter-dependence

Charismatic megafauna…

depend on non-charismatic microfauna



Habitat Structure: Complexity

Complexity (Habitat)

- In-channel
- On banks
- On bed

- Complexity (habitat) is provided by:
  - Vegetation
  - Substrate
  - Dead wood (LWD)
  - Depositional features
  - Bed features
  - Erosional features
  - Dynamic planform

Good habitat is messy

(perception conflict: good engineering designs are neat)

Bed Complexity: Pools/Riffles and Step-Pools

Planform Complexity

- River adjustment creates habitat for multiple species and multiple life stages
  - Riffles
  - Pools
  - Side Channels
  - Riparian Wetlands
  - and more

Rivers are Dynamic

Rivers transport sediment

- Pools and riffles (habitat) are created by erosion and deposition
- Healthy rivers erode, but not excessively (sediment balance)

Characteristics of Healthy Rivers

- Water quality
  - Dissolved oxygen
  - Temperature
  - Pollutants
- Water quantity
  - Natural flow regime
- Complexity (Habitat)
  - In-channel
  - On banks
  - On bed
- Connectivity
- Sediment balance
  - Healthy rivers erode and deposit in balance

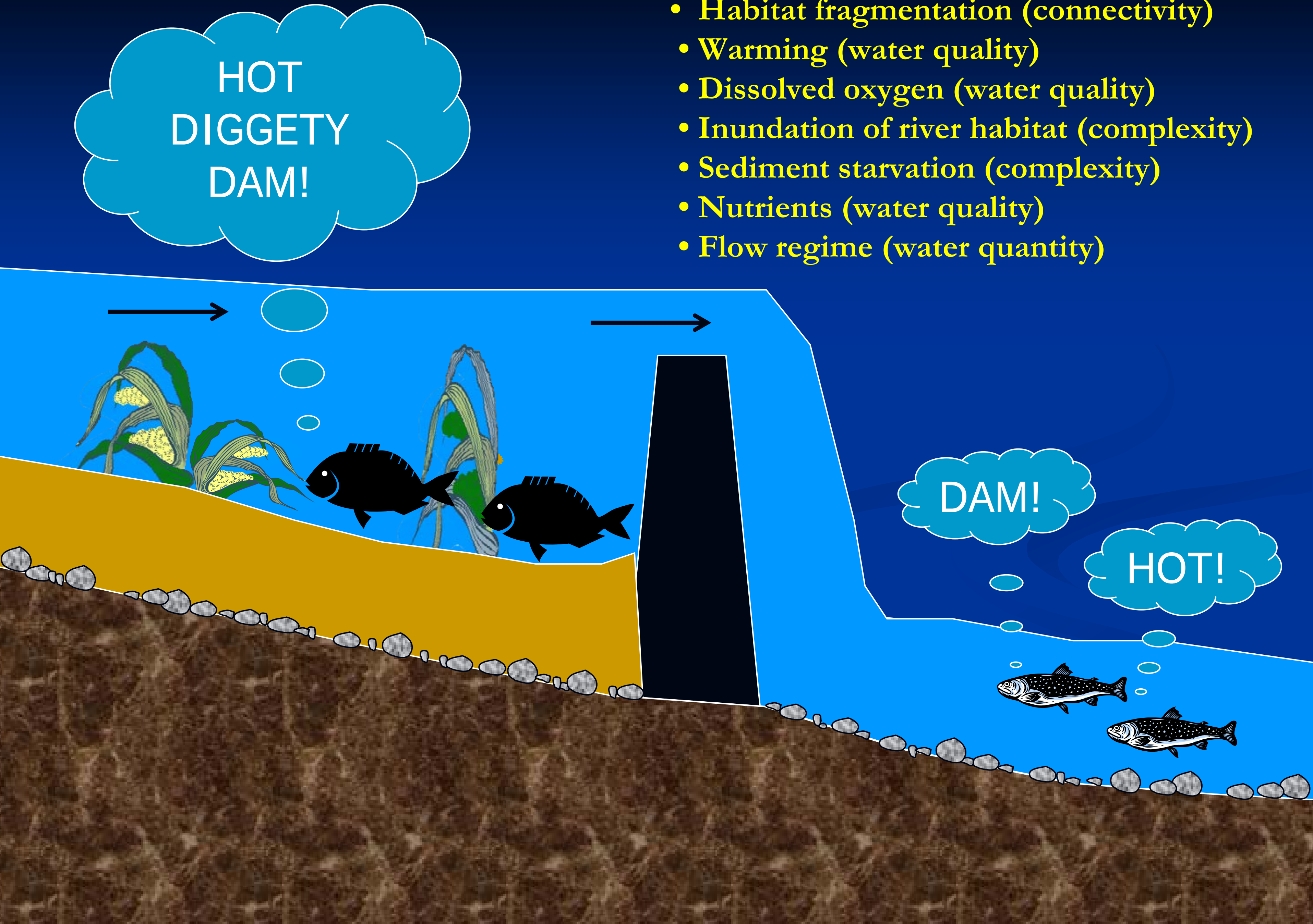
Dams impact each of these characteristics

Dam removals need to address each of these characteristics


Dam Impacts

Dams impact every aspect of healthy rivers (in impoundment and downstream):

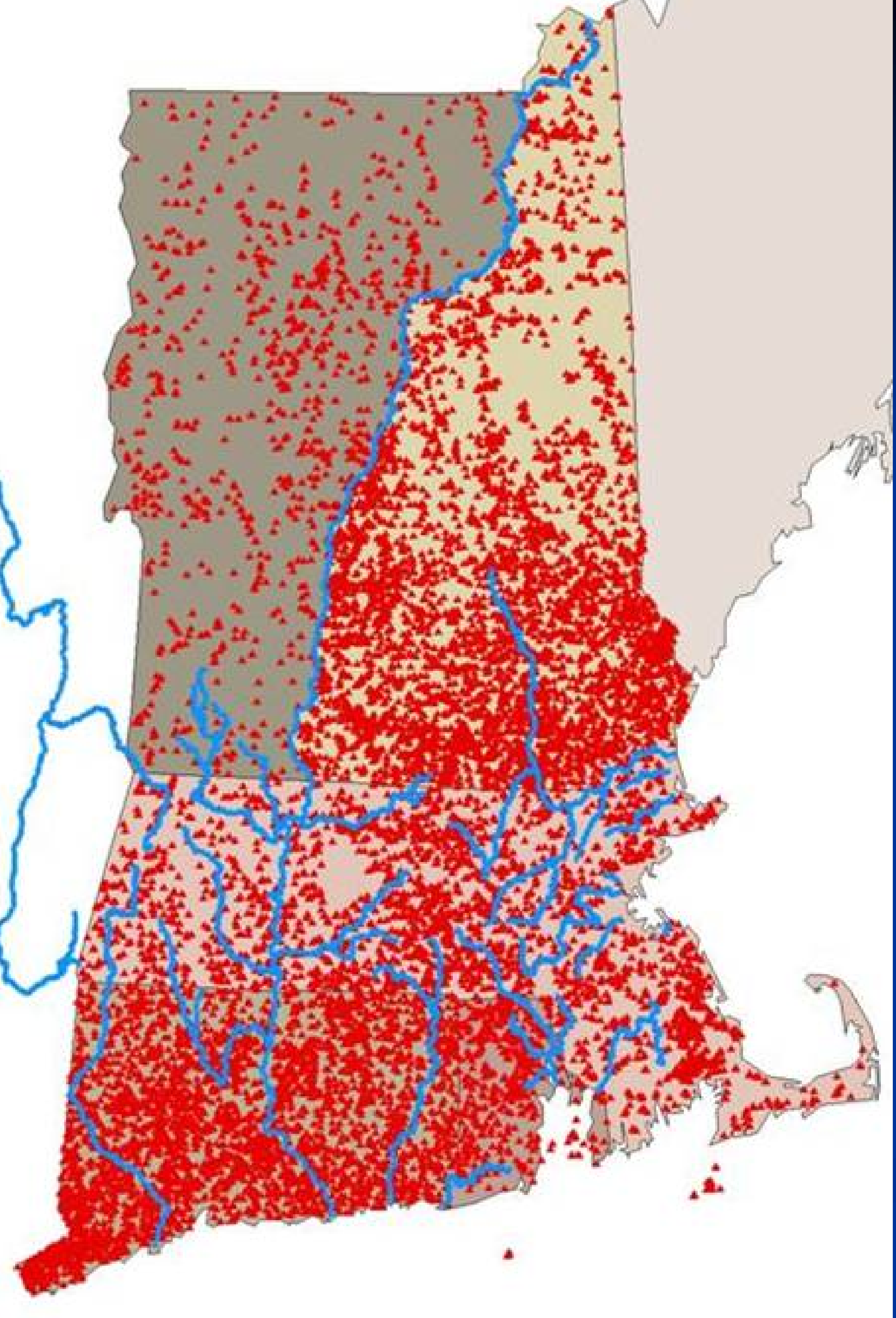
- Habitat fragmentation (connectivity)
- Warming (water quality)
- Dissolved oxygen (water quality)
- Inundation of river habitat (complexity)
- Sediment starvation (complexity)
- Nutrients (water quality)
- Flow regime (water quantity)



Large Dam (Additional) Impacts

- Distinction between large and small dams
- Large dams
  - No more overbank flows (Magilligan and Graber paper)
  - Loss of diversity and riparian wetlands
  - Downstream riverbed degradation – no sediment transport (19 ft degradation over 25 years on Colorado River downstream of Davis Dam)
  - Thermal inversion – coldwater release

Dams fragment habitat for multiple species



13,126 Dams in CT, RI, MA, VT, NH (databases)

Land Area
CT,RI,MA,VT,NH = 31,900 sq.mi.
WI = 54,300 sq.mi.
PA = 44,800 sq.mi.

The loss of river habitat has restricted species that depend on flowing water to a fraction of their former habitat

Dam Effects on Diadromous Fish Populations

- Atlantic salmon – extirpated from most of east coast U.S. by early 1800s in large part due to dams
- Other anadromous fish like herring, shad, sturgeon, lamprey, smelt, and striped bass also suffered dramatic population declines and many rivers lost these species completely
- American eel - being reviewed by the federal government for threatened/endangered status because of dramatic population decline
- But, fragmentation affects all aquatic species (connectivity)

Water Quality

- Nutrients accumulate in impoundments
- Respiration and decay of vegetation can result in dissolved oxygen declines
- Warming temperature in the summer – additional impact on DO

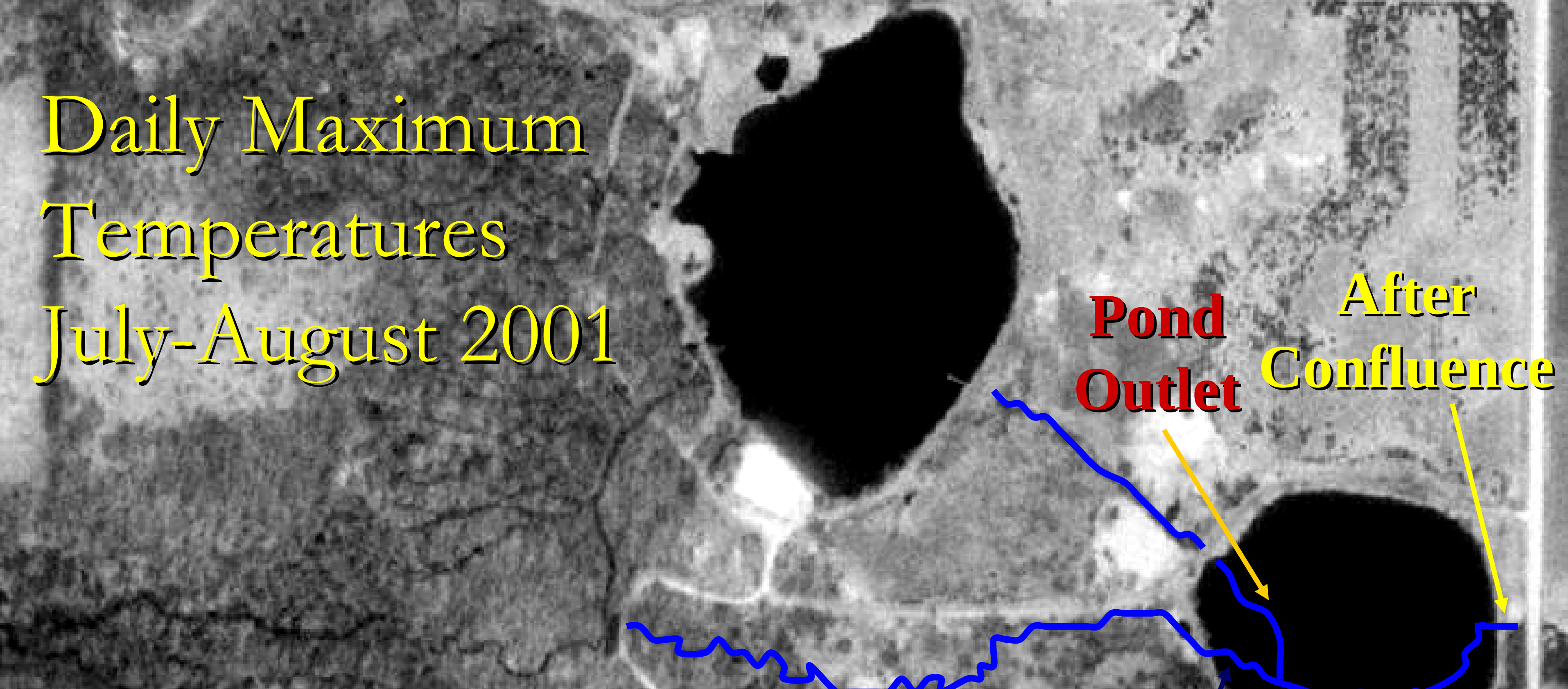
Dam Impacts on Resident Species
Example: Coldwater Habitat Thermal Needs

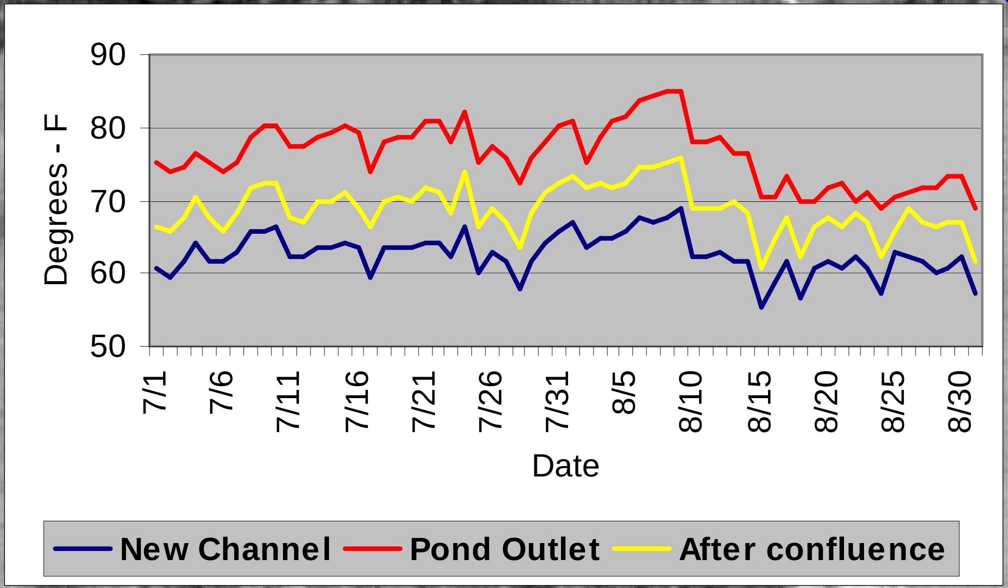
Photo by Tim Watts

Brook trout (northeast U.S. native):

- Optimum range is 50 to 60 °F
- Mortality can occur at 75 °F
- Optimum spawning range is 40 to 50 °F

Daily Maximum Temperatures July-August 2001





With identical cold spring sources:

- Flow from small impoundment has lethal temperatures
- Flow in restored channel has appropriate temperatures

Dam Impacts on Other Aquatic Species

Mussels - of the 12 species of mussels in Massachusetts, 7 are classified as imperiled

"The decline of freshwater mussels, which began in the late 1800's, has resulted from various habitat disturbances, most significantly, modification and destruction of aquatic habitats by dams and pollution." (National Biological Service)

Nearly half of the 496 animal species federally listed as threatened or endangered are freshwater species.

Aging Infrastructure

- Dams have a finite design life
- Many were originally built to power industrial revolution
- Built/rebuilt over hundreds of years
- Dam failures are outpacing removals in many places

Dam Owners and Dam Removal

- Repairing/rebuilding an aging dam typically costs more than removal
- Repeated repairs
- Operations and maintenance
- Liability
  - Failure (flooding and sediment)
  - Public safety (attractive nuisance)

Removal is a one-time cost

Potential Community Benefits

- Exposed land uses:
  - Riverwalks
  - Parks
- Recreation: fishing/boating access and opportunities
- Revitalization
- Relief of water quality problems
- Aesthetics

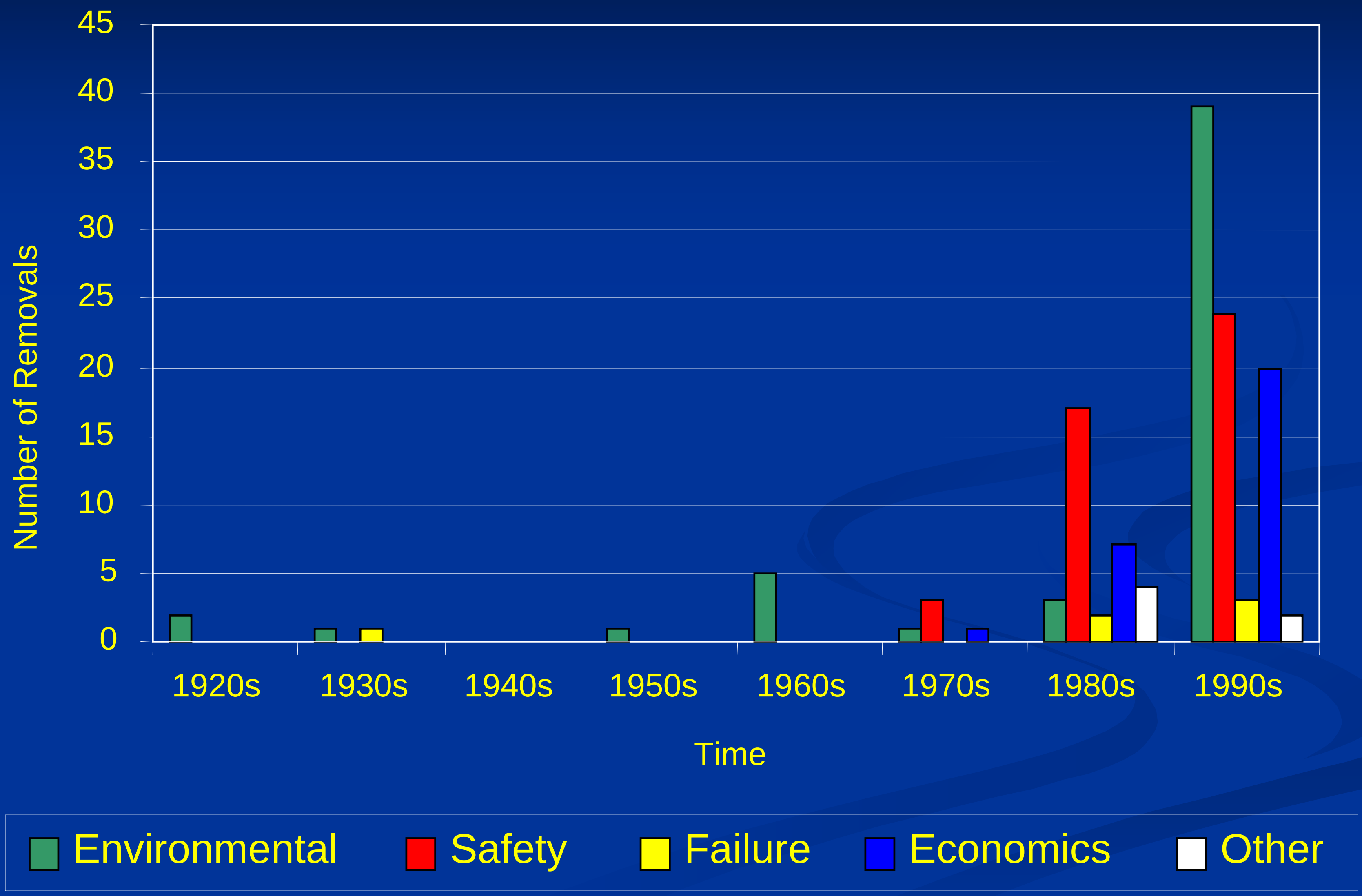
Dam removal can be a win—win—win scenario for:

- dam owners
- community
- habitat

Dam Uses

- Many dams serve important purposes:
  - Water supply (residential, industrial, farm ponds, fire ponds, irrigation)
  - Flood control
  - Hydropower
  - Recreation
  - Mine waste control
  - Waterfowl habitat
  - Navigation
- Hydropower and flood control make up a small percentage of dams
  - Even for the largest dams (NID) 14.6% are flood control and 2.9% are hydropower
- Societal interest in dams
- Along with uses and sheer number, dams are and will be a part of river environments

Dam Removal Purpose By Decade



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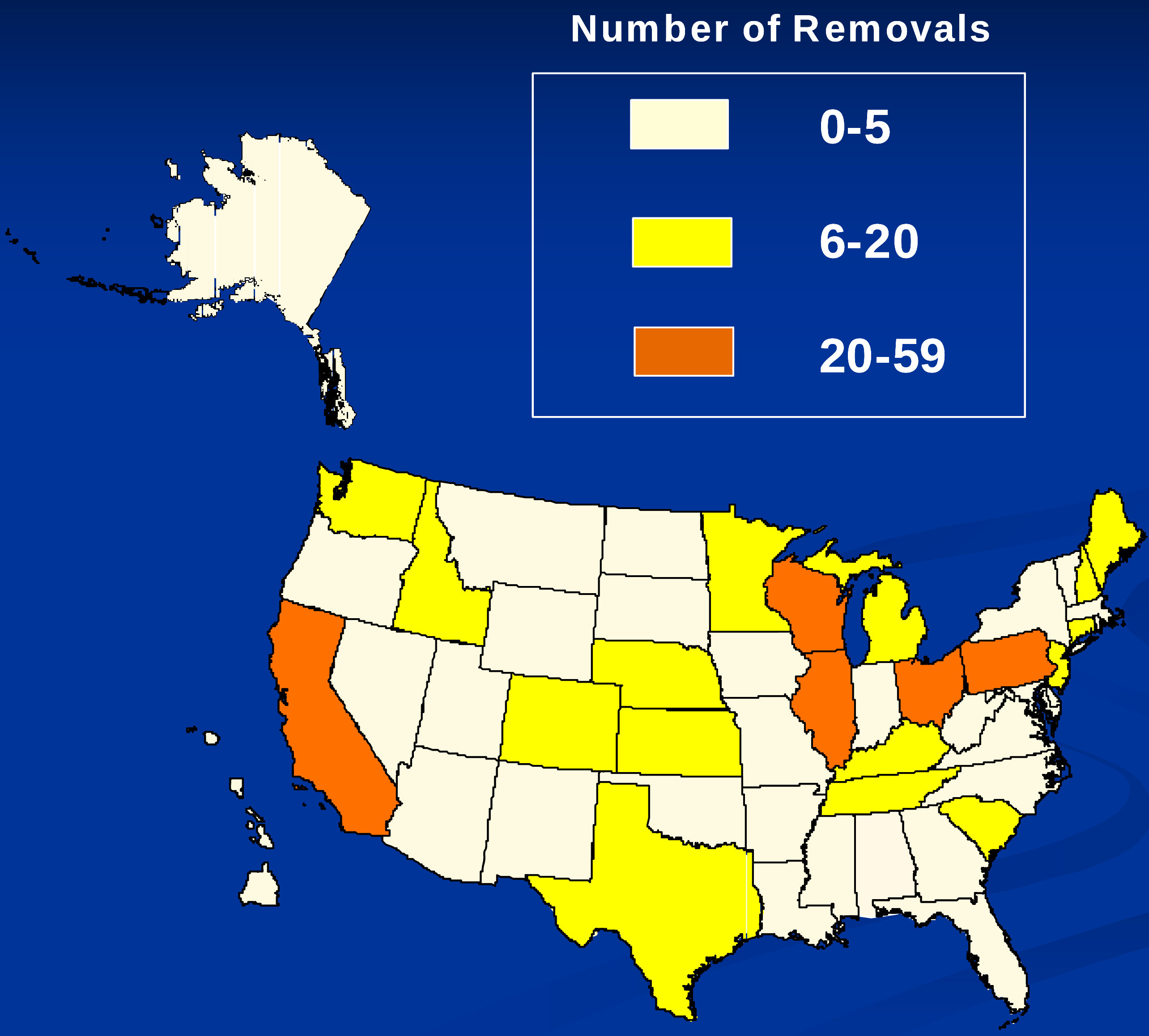
Source: Molly Pohl
San Diego State University

Number of Dams Removed by State



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Dam Removal Numbers

- More than 650 dams have been removed around the country (more than 200 since 1999)
  - PA (14) and MA (3) both set records this year
- We are removing and have removed a very small percentage of dams
  - 75,000 dams on national inventory
  - Estimate of actual number is between 200,000 and 2 million

Dam Removal Clearinghouse:

http://www.lib.berkeley.edu/WRCA/damremoval/index.html


Dam Removal Components

Dams are not equal

- Sediment quantity
- Sediment quality
- Dam size
- Dam condition
- Impoundment size
- Impoundment shape
- Surrounding infrastructure
- Surrounding environment

<u>Aspen Institute Recommendation #1:</u>

The depth and type of analysis…should reflect the scale of the project and scope of the project's impacts.

What makes a good dam removal?

- Restored natural processes (4 aspects of river health)
- Protecting infrastructure
  - Upstream infrastructure
  - Under stream infrastructure
- No long-term environmental damage
- Two situations where short-term impacts can become long-term damage:
  - Uncontrolled contaminant release
  - Direct impacts on imperiled species
- Both situations can be effectively managed (at more expense)

Process is Designed To Consider

ENGINEERING

DATA COLLECTION
TYPE & CONDITION OF DAM
SITE LIMITATIONS (Utilities, Topo)
UPSTREAM & DOWNSTREAM ISSUES
(bridges/structures, tributaries)
ALTERNATIVES ANALYSIS

SOCIOECONOMIC

OWNERSHIP (Water Rights; Easements)
CURRENT USES
RECREATION
PUBLIC SAFETY
ECONOMIC ANALYSIS
ARCHEOLOGICAL/HISTORICAL
SENTIMENTAL VALUE
AESTHETICS

ECOLOGY

ANADROMOUS / RESIDENT FISH
AQUATIC HABITAT
HABITAT FRAGMENTATION
ECOLOGICAL INTERCONNECTIONS
VEGETATION
WILDLIFE
SPECIES OF SPECIAL CONCERN

WATER QUALITY

CHEMICAL PROPERTIES
PHYSICAL PROPERTIES
(i.e. temperature, turbidity)
PUBLIC HEALTH

HYDROLOGY

WATERSHED HYDROLOGY
FLOODWATER STORAGE
IMPOUNDMENT DRAWDOWN
WELL IMPACTS

HYDRAULICS

CHANNEL HYDRAULICS (&safety)
FLOODPLAIN HYDRAULICS
ICE JAMS

FLUVIAL GEOMORPHOLOGY

TESTING (quality & quantity)
SEDIMENT STABILITY/TRANSPORT
SEDIMENT MANAGEMENT
SEDIMENT DISPOSAL
CHANNEL MORPHOLOGY/DESIGN (form, function, process, materials)
SITE RESTORATION

CONSTRUCTION

SEASONAL CONSTRUCTION LIMITS
CONSTRUCTION ACCESS
CONSTRUCTION SEQUENCE
WATER CONTROL

PERMITTING

FUNDING

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Dam Removal Components

- Initial Reconnaissance
- Fundraising
- Feasibility Study/Concept Design
- Community/Stakeholder Involvement
- Permitting (and pre-permitting)
- Engineering and Restoration Design
- Construction
- Monitoring

- Steps are not necessarily in this order
- Again, level of effort should reflect scale of project

General Issues

- Dam removal is extremely multidisciplinary
- Dam removal is extremely collaborative
  - No one entity knows how to do every step

- Timeframe: 3-year process
  - Year 1: reconnaissance and feasibility
  - Year 2: design and permitting
  - Year 3: implementation
  - Community involvement and fundraising throughout

- Different states have different regulatory processes and agency streamlining, making each step more or less extensive

Initial Reconnaissance: Deciding if project is worth pursuing

- Identify the scope of the project and specific challenges
- Dam owner must be on-board or mandated (can't just pick a dam and remove it)
- Preliminary Assessment:
    1) Threatened and endangered species issues – check with local, state, and federal agencies, GIS
    2) Contaminants – consider past industry, 303(d) list, or core
    3) Infrastructure – retaining walls, bridges, buildings, utilities, etc.
    4) Current dam uses – can they be replaced?
    5) Land ownership around impoundment
    6) Public interest
    7) Potential funding "hooks"

Consider how these issues affect the cost and scale of the project

Fundraising

Some funding possibilities:

- NOAA (grant programs for anadromous fish)
- NRCS (WHIP and other grant programs)
- USFWS (several grant programs)
- Private foundations
- state agencies
- ACOE section 206 restoration funds (for big projects)
- CWRP
- Mitigation funds

Service assistance:

- State agencies
- Non-profits (American Rivers, The Nature Conservancy, Trout Unlimited, and others)
- Volunteers
- Military
- Universities

- Matching funds: contribution from dam owner

- Winning funding:
  - Involve funders
  - Collaborative projects
  - High likelihood of completion
  - Preliminary assessment work done
  - Support letter from owner

Fundraising

Some Challenges:

- Paying for ancillary, but critical, issues – i.e., replacing water supply, moving sewer pipe, deed research
- Need to define costs early (can be a challenge)
- Piecing together funding (can be complex)
- Carefully consider funding deadlines – these can be long-term projects

Feasibility Study
(a.k.a. Alternatives Analysis, Concept Design)

Evaluates site-specific challenges and approaches to provide basis for decision-making on what will go into final design

- Complete analysis to develop alternatives for
  - Structure removal
  - Infrastructure protection
  - Habitat restoration (instream and riparian)
  - Sediment management
- And sometimes:
  - Permitting
  - Community/stakeholder involvement
- Develop cost estimates for preferred alternatives

Feasibility Study Components

- Data collection
- Survey and mapping
- Hydrology and hydraulics
- Infrastructure plans and approaches
- Ecology
- Channel and riparian restoration plan
- Sediment transport and management
- Structure removal plan
- Site-specific issues
- Permitting assessment
- Cost estimating
- Pre-project monitoring

Not all projects require all of these (but should consider the need for each)

Feasibility Study Components: Data Collection

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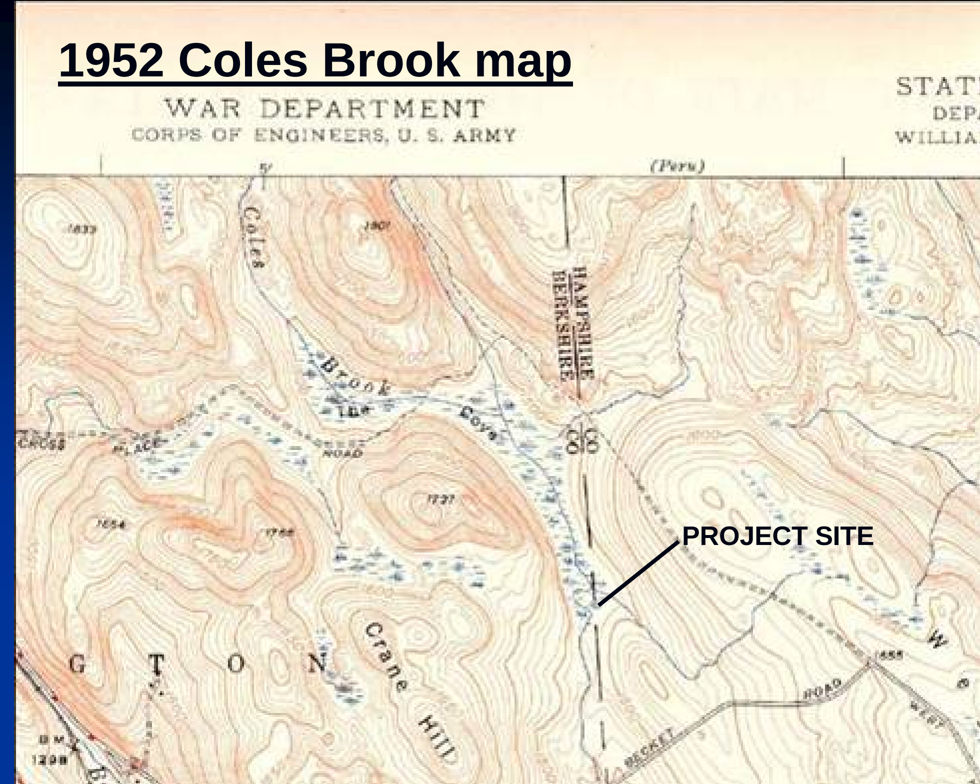
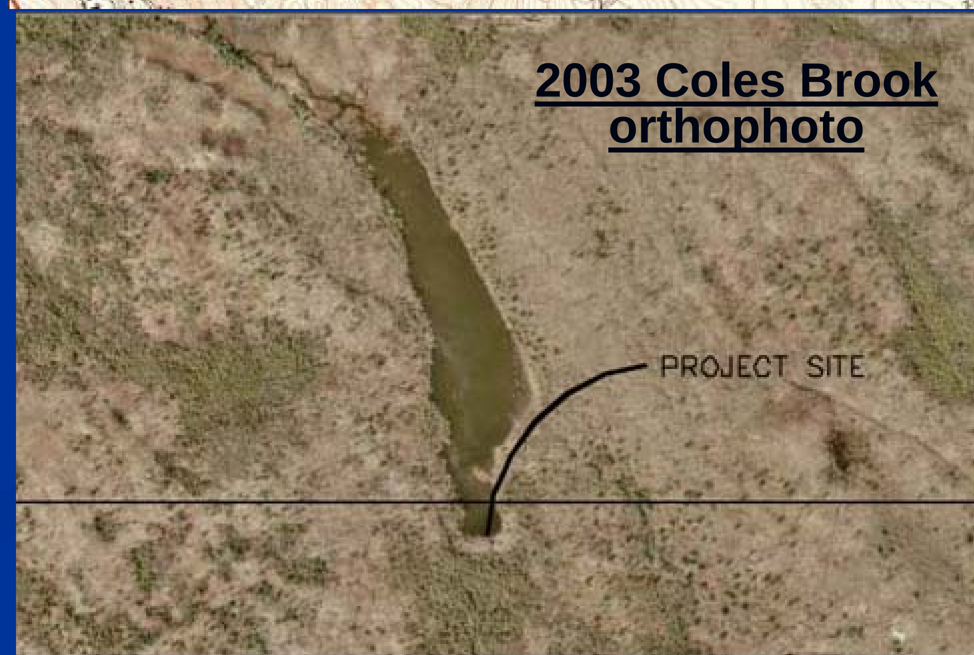
- Past Dam Inspections (state dam safety)
- FEMA - FIS, profiles, plans, and computer model (state, town library or engineer), or
  http://www.msc.fema.gov
- Aerial or orthophotographs (web or order)
  http://maps.google.com
  http://earth.google.com
- USGS topographic mapping
- Local topographic mapping (town, state, web)
- Sanborn mapping (commercial properties to 1867):
  http://www.edrnet.com/sanborn.htm
- Historic topo maps: http://historical.maptech.com
  For northeast:
  http://docs.unh.edu/nhtopos/nhtopos.htm
- Tax Assessors Mapping (town)
- Geological mapping
- GIS Data (town, region, or state)
- State Rare & Endangered Species Mapping
- Wetland Mapping
- Stream Data (state)
- EPA Watershed Mapping & Info
  http://www.epa.gov/surf/
- USGS Gauge Data (flow & sediment)
  http://water.usgs.gov/
- Additional Flow Data (state, web, ACOE, local group, old reports)
- Fisheries Data (state)
- Past Plans (of dam, site, or nearby construction) (DOT, town engineer, state)
- Permit applications (town, state, feds, or web)
- Old Reports (environmental, historic, engineering, planning, state studies, etc.)
- Photographs (current and historic) (town, neighbors)
- Historic Records (town, state)
- FERC Reports: http://elibrary.ferc.gov
- Utility Information (town or state)
- Web pages for local recreation

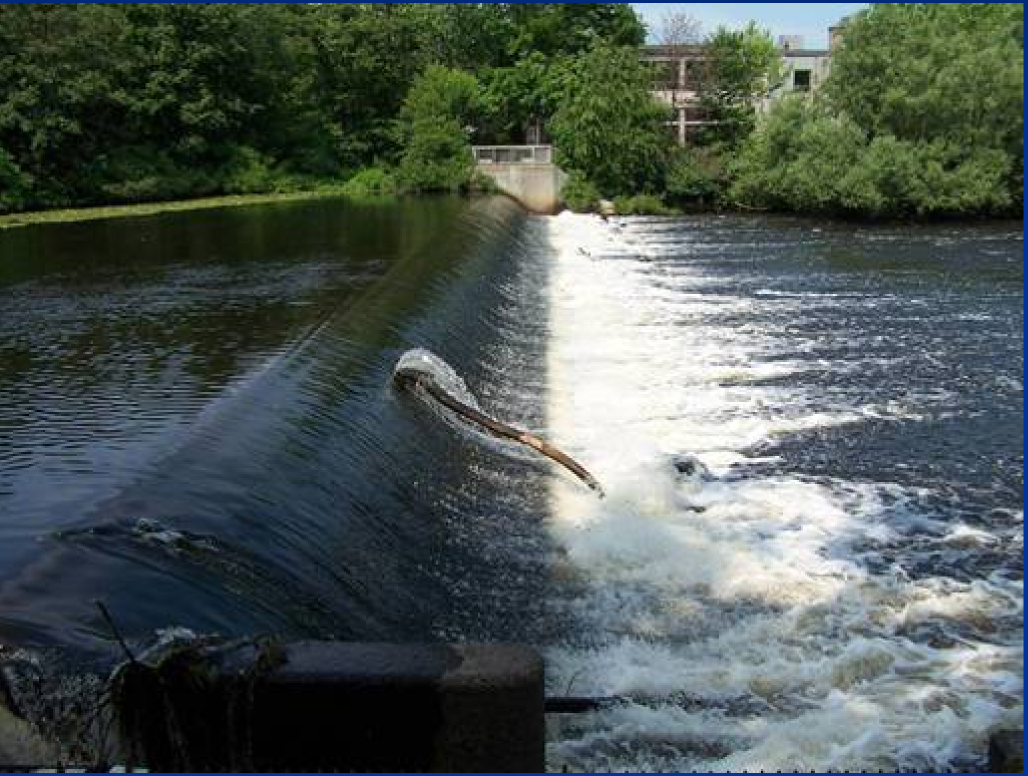
Feasibility Study Components: Data Collection

Good existing data can help shape decisions on project approach





Feasibility Study Components: Structure Removal Conceptual Plan

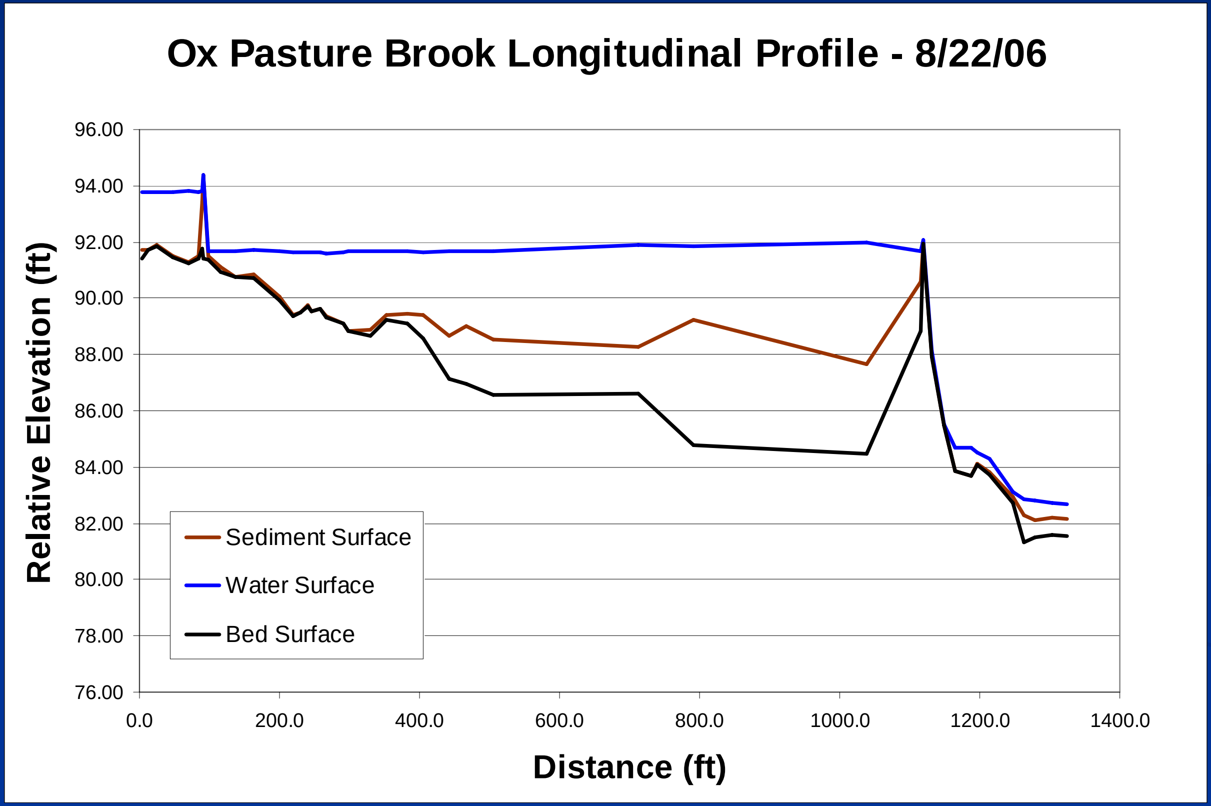


- Assess condition of structure
  - Safety
  - Demolition approach
  - Usable gates, removable boards, etc.
- Access
- Site limitations
  - topographic
  - utilities

Feasibility Study Components: Survey and Mapping

- Minimum detail:
  - Longitudinal profile – rule of thumb: upstream to height of dam; downstream to next bed control
  - Cross sections – through impoundment, upstream, and downstream; measure at every major change of cross section size and shape
  - Capture area around the dam and utilities with more detail
- Must get in water!!!
- Resource area delineations for permitting
- Survey equipment – must use equipment that can penetrate water
- Identify or establish benchmarks (check regulations for datum)
- Measure depth to refusal

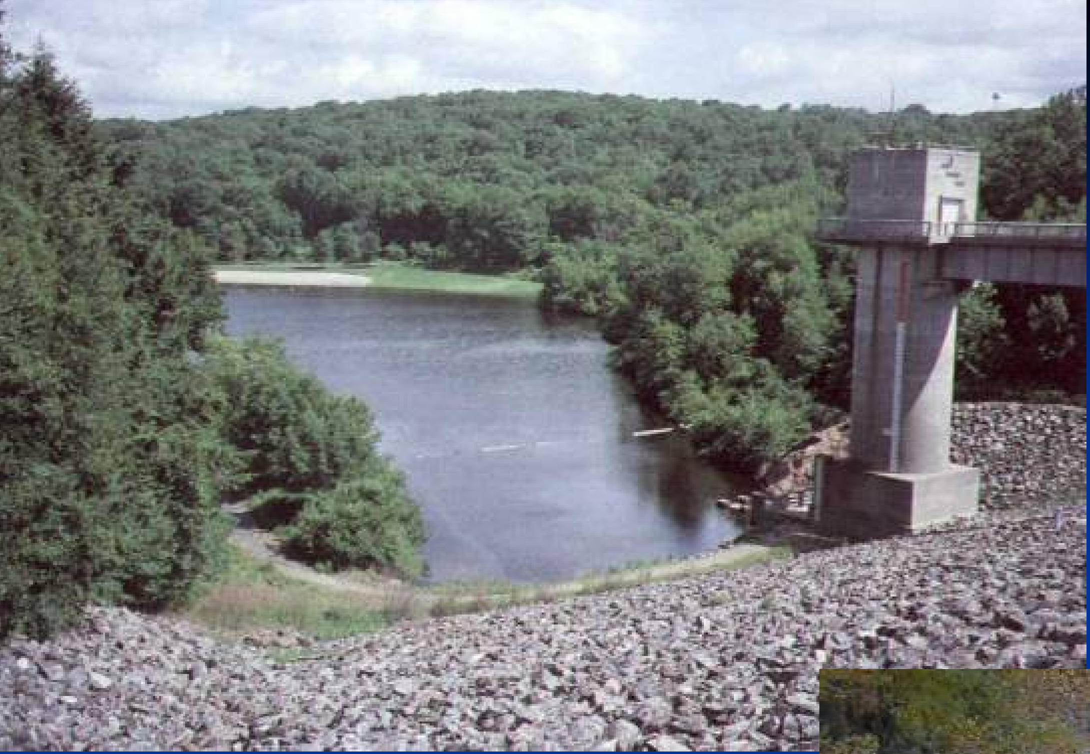
Longitudinal Profile:
fundamental analysis tool



Feasibility Study Components: Hydrology and Hydraulics

- Hydrology: assessing magnitudes and probabilities of flows (freshwater and tidal)
  - Use multiple techniques (Maidment 1994, Handbook of Hydrology):
  - Gauge measurements; Gauge transfer; USGS regression equations (regression equations available on downloadable National Flood Frequency Program)
  - flow measurements (to calibrate and verify to extent possible)
  - Cross section survey with Mannings Equation
  - TR-20 and TR-55 – intended for small watersheds
- Hydraulics: assessing depths and velocities of flows
  - HEC-RAS or other models
- Flood control – how will flooding change (assess flood control, because you <u>will</u> be asked)

Flood Control



No Flood Storage Potential: has full impoundment and constant flow over spillway

Flood Storage Potential: has storage volume and flow through a controlled outlet

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Feasibility Study Components: Infrastructure Protection

- Utilities – can they be moved?
- Bridges and culverts - assess scour potential
- Retaining walls
- Buildings
- Assess upstream and downstream of dam, and under impoundment
- Consider construction vibration impacts on infrastructure

Feasibility Study Components: Sediment Transport and Management

- Assess sediment:
  - Quantity – from survey and refusal depths
  - Quality – cores from fine-grained material
  - Mobility – not all sediment in impoundment moves
- Assessment techniques:
  - Simple: longitudinal profile and pebble counts
  - Complex: sediment transport models

Some General Sediment Thoughts

- Consider background sediment yield of river
- Consider downstream sediment condition
- Not all dam impoundments have a lot of sediment
- Not all sediment moves
  - one study estimated 21% of impounded sediment moved over time (Graber 2003)

Part 1:
Initial sediment
release

Part 2:
Long-Term
Erosion

Feasibility Study Components: Contaminants

- Testing
  - Assess quantity of sediment
  - Physical and chemical parameters
    - Organics
    - Heavy metals
- Management
  - Removal and disposal
  - Isolating and capping
- If contaminant management is necessary, can greatly add to cost of project

Feasibility Study Components: Sedimеnt Management Options

- Natural erosion
  - “blow and go”
- Sediment removal
  - dredging
- Sediment stabilization
  - Slow or incremental drawdown
- Combination

Feasibility Study Components: Ecology and Fish Passage

- Target species vs. stream simulation (connectivity)
  - Design first for stream simulation, then check target species
- Incorporating habitat components (complexity)
  - Substrate
  - Woody habitat
- Wetlands – creating, restoring, decreasing?
- Threatened/endangered species of concern

PASSAGE REQUIREMENTS FOR TARGET FISH SPECIES

Species	American shad	Alewife	Blueback herring	Sea-run brown trout
Life Stage	adult	adult	adult	adult
Migration	Apr-July	Apr-June	Apr-July	Oct-Dec
Min. Water Depth	7-9 in.	5 in.	5 in.	5 in.
Cruising Speed	2.8 fps	2.8 fps	2.8 fps	2.8 fps
Sustained Speed	7.6 fps	4.8 fps	4.8 fps	7.2 fps
Burst Speed	14.8 fps	6.8 fps	6.8 fps	12.8 fps

SLIDE MODIFIED FROM:
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Source for Fish Graphics: Henry W. Robison and Tryckare, Cagner, and Moss

Protecting Aquatic Species

- Timing the removal
- Surveying, protecting, relocating species of concern
- Effective sediment management

Feasibility Study Components: Channel and Riparian Restoration Plan

- Restore 4 aspects of river health
- Active vs. passive channel design
- Why actively design?
  - Limit erosion and provide stability
  - Restore habitat sooner
  - Aesthetics
  - Depends on impoundment type
- Most important aspect of bank stabilization is channel configuration; not how hard the banks are
- Simulate nature for habitat and stability

Revegetation

- Active vs. passive
- Why actively revegetate?
  - Exotics
  - Invasive monocultures
  - Erosion control
  - Aesthetics
- Aggressively plant
  - Annual rye immediately
  - Native seeds, cuttings, seedlings
- Good habitat is messy

phragmites

purple loosestrife

Feasibility Study Components: Pre-Restoration Monitoring

- Incorporate into feasibility
  - Permanently monument cross sections and benchmarks
  - Species assessments
  - Photograph site extensively
    - Create photo stations
    - Consider future site changes

Feasibility Study Components: Permitting Assessment

- Assess likely regulatory thresholds
  - Changes to resource areas
  - Dredge and fill quantities
- Some cases, complete historic/archaeological study

Feasibility Study Components: Site-Specific Issues

- Ice jams
- Wells – groundwater study?
- Replacing or altering uses (withdrawal pipes, water supply tanks, etc.)
- Recreation plan – parks, river walks, boating/fishing access
- Community involvement plan (renderings)
- Anything else?

Feasibility Study Components: Cost Estimating

- For multiple alternatives
- Based on:
  - Past experience (very regional)
  - Estimating tools such as RS Means Manual
- Cost estimating at this stage is an art and a science
- Present a likely spread or contingency percentage

Feasibility Study Components: Outcomes

- Feasibility report
  - Describes analysis
  - Describes alternatives
  - Supports decision-making
- Concept drawings
- Cost estimates

Dam Removal Components

- Initial Reconnaissance
- Fundraising
- Feasibility Study/Concept Design

- **Community/Stakeholder Involvement**

- Permitting (and pre-permitting)
- Engineering and Restoration Design
- Construction
- Monitoring

Stakeholder/Community Involvement

- Ignore at your peril
- Contentiousness is unpredictable – may be some basic principles, but not really
- Frequent concerns (may throw anything at you because of change):
  - Flood control
  - Mudflats
  - Wetland loss
  - Historic
  - Recreation changes
  - Property values

Stakeholder Input

Digital rendering by L. Wildman, American Rivers

- When to bring in community and stakeholders – difficult question – early in process is usually best
- Involve <u>all</u> stakeholders
- Public visioning – dam removal is a "loss"; provide a sense of "gain"
  - May develop renderings during feasibility to provide vision

This is not real –

it is a digital drawing!!!

Focusing on True Barriers

	Action: Remove Dam	**Competing Action: Fix Dam**	**Competing Action: Do Nothing**
Perceived benefits	• Cheaper than fixing it • Removes danger and liability • Good for habitat • May create impetus to remove other dams on the river and restore the smelt run • Increased river recreation	• Keep the pond • Things stay the same	• No effort • Won't be told what to do • Cheap
Perceived barriers	• Fear of change • Loss of the pond • Possible loss of campground or angry feelings from owners • Difficulty due to permitting, costs, management • Loss of alewife habitat • Don't want to be told what to do by outsiders • Mixed message from "experts"	• Expense • They would own the liability • Long term maintenance • They must own the dam and go through a long real estate process	• May lose the pond • May lose the campground • May face damage to downstream structure • Danger to life and property • Will be left with a failing structure that has no ownership Approach from: McKenzie-Mohr and Smith, 1999

Pre-Permitting

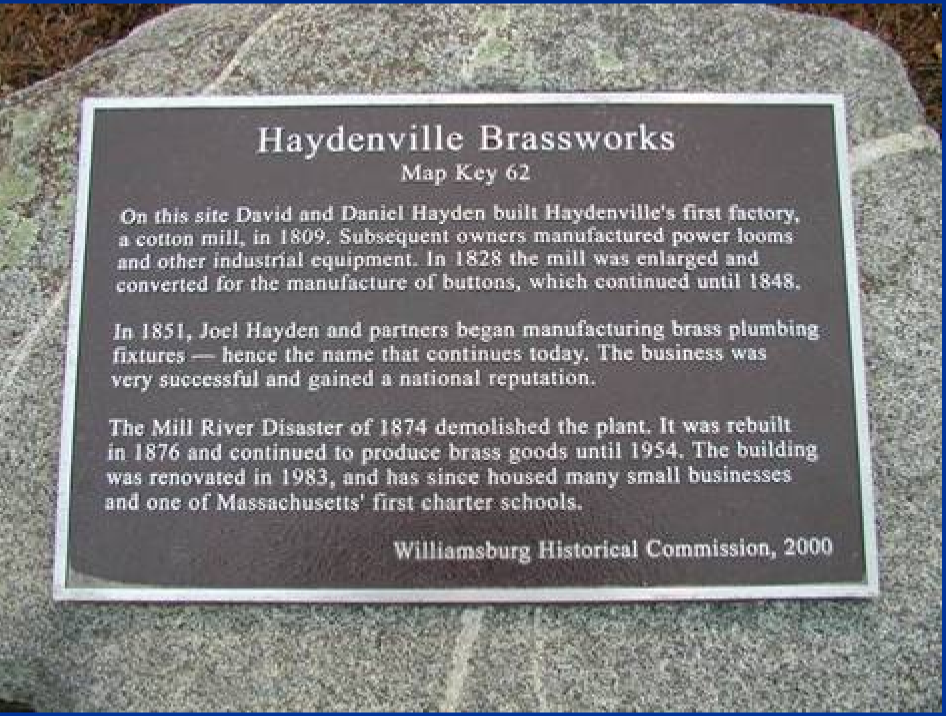
- Confirm regulatory requirements
  - Different everywhere

- When to have this meeting
  - Definitely before engineering design
  - Depends on environment
    - Earlier and ask
    - Later and propose

Engineering and Restoration Design Components

- Design plans (stamped by professional engineer) should show:
    - Current conditions
    - Staging and access
    - Removal plan – staged drawdown, open gate, etc.
    - Regulatory resource areas
    - Dewatering plan (sometimes done by contractor)
    - Proposed cross sections
    - Proposed longitudinal profile
    - Proposed plan view
    - Infrastructure replacement/protection
    - Habitat components and schematics:
        - Erosion control fabric installation
        - Woody habitat
        - Planting plan
- Specifications
    - Includes equipment, materials, quantities
    - Describes construction specifics
- Construction Sequencing Plan
- Cost estimate – engineer's probable cost until contractor bid

Permitting



- Federal, state, and local
- Usually, permitting is NOT just preparing paperwork. Also includes:
  - Attending public regulatory hearings
  - Consultation with regulators
- Restoration waivers, process streamlining: PA, NH, MA
- Tip: work together with regulators
- Specific challenges: wetlands, historic, etc.

Project Implementation

- Construction crew: contractor, state agencies, military training, volunteers
- Oversight
  - By designer
  - At all times
- Timing – dictated by permits

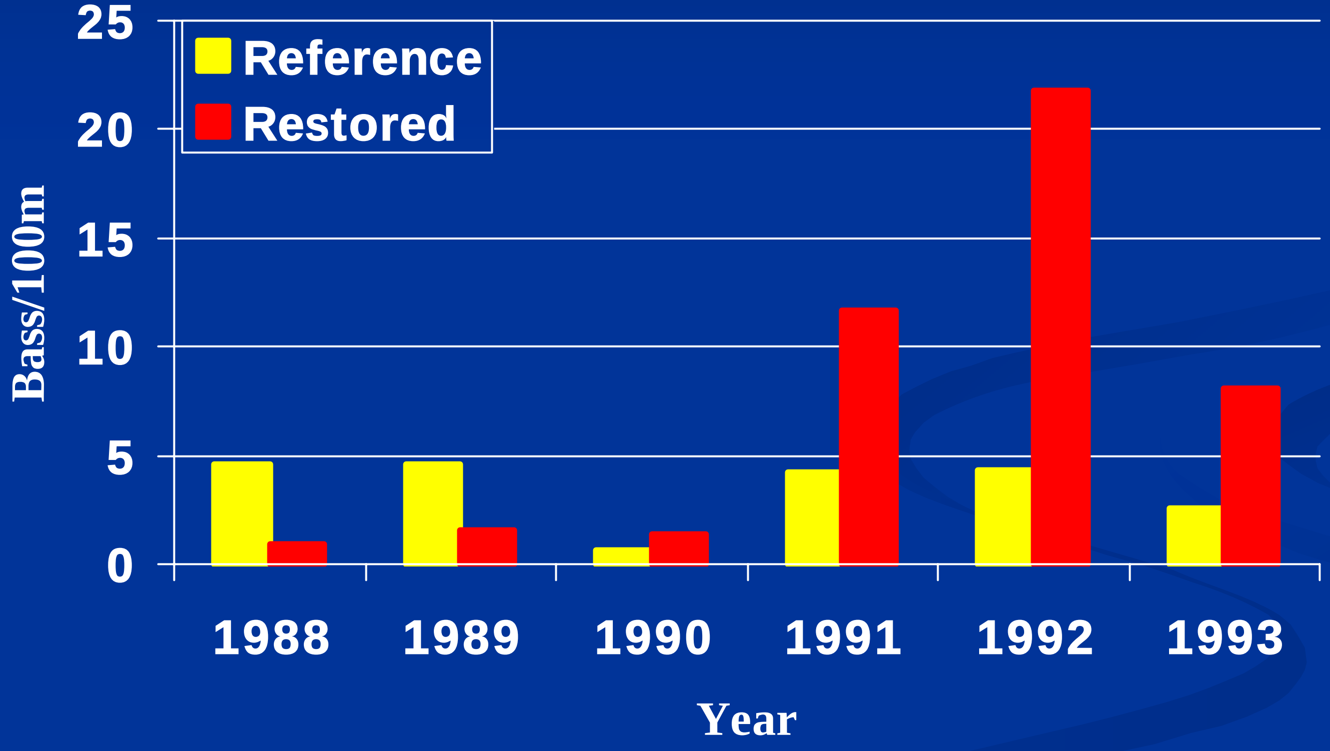

CAT

Post-Removal Monitoring

- Learning and discovery time
  - Even if not paid to do it…do it
- Gulf of Maine Council Workgroup – developing monitoring guidelines
- Two Aspects:
  - Short-term site monitoring – infrastructure, erosion, etc.
  - Long-term ecological and geomorphic response
    - Photo stations
    - Permanent cross sections
    - Repeated longitudinal profiles
    - Macroinvertebrate and fish sampling
    - Others based on project concerns

Enhanced Fishing through Increased Game Fish Abundance

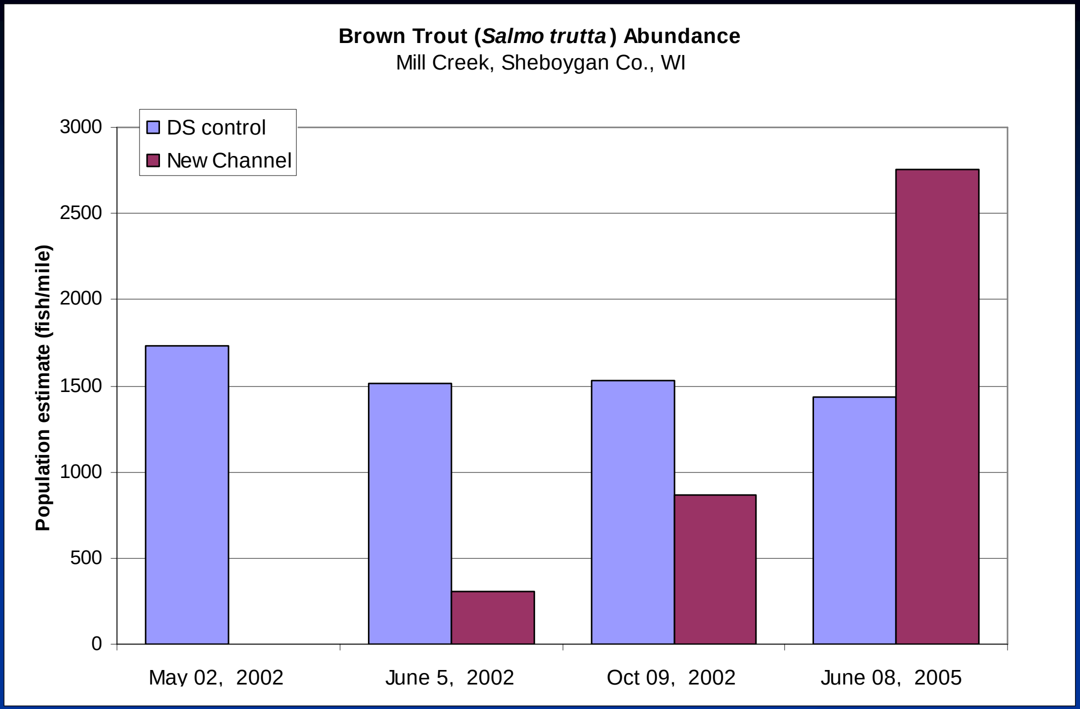
Smallmouth Bass Response, Milwaukee River, WI



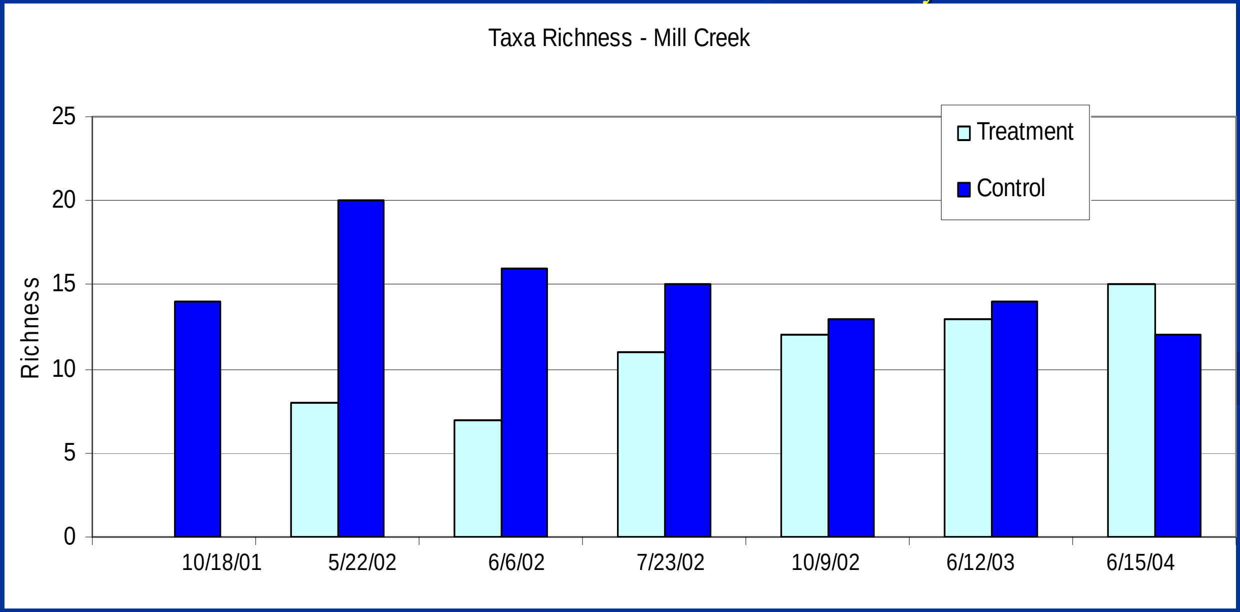
From Kanehl et al., 1997

SLIDE MODIFIED FROM:
Wildman, American Rivers

Silver Springs Dam Removals Results: Fisheries and Macroinvertebrate Response



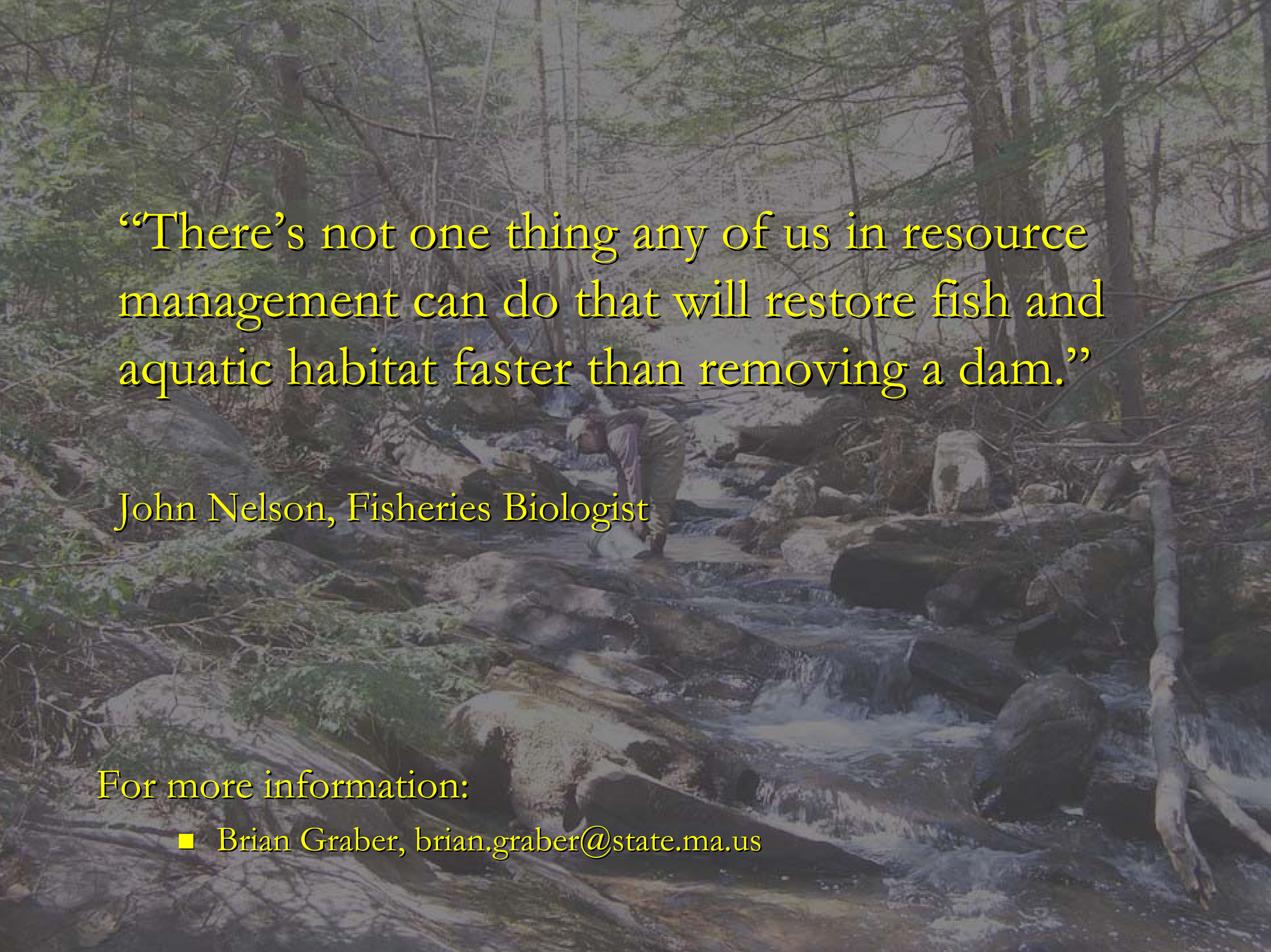
Dams removed at end of May 2002



Diagrams from M. Melchior

Challenges and Recommendations

- Know the site!!!
- Remove as much of dam as possible – especially vertically
- Good habitat is messy – don't be neat and clean
- Be ready for contingency plans for changes in process – always an issue that arises
- Don't require an entire list of services because you saw it at a short course – scope should fit scale



"There's not one thing any of us in resource management can do that will restore fish and aquatic habitat faster than removing a dam."

John Nelson, Fisheries Biologist

For more information:

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